

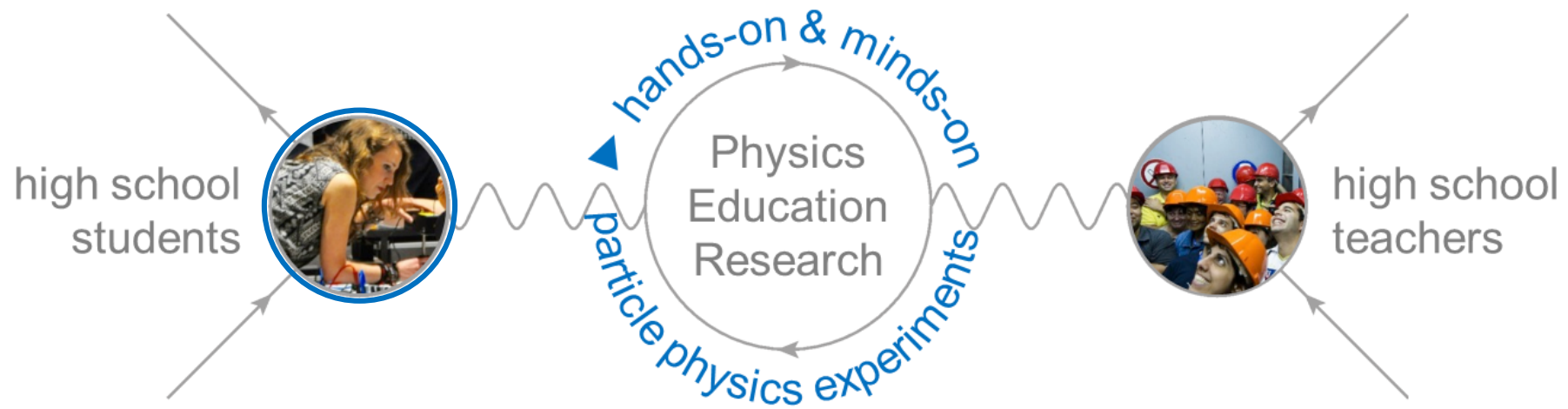


S'Cool
LAB



Idea Circle Dinner Discussion #3 | cern.ch/s-cool-lab | 17 April 2019 IdeaSquare, CERN

S'Cool LAB: From hands-on learning activities to questionnaires and escape games



Current opportunities

Cloud Chamber WS



A 90-minute hands-on particle physics workshop for high school students (aged 14 and above) and high-school teachers.

6370 participants in 2018
(5420 students & 950 teachers)

S'Cool LAB PLUS+



A half-day programme for high school students (aged 16-19) which includes cloud chambers, + one additional experiment, + participation in PER projects.

650 participants in 2018

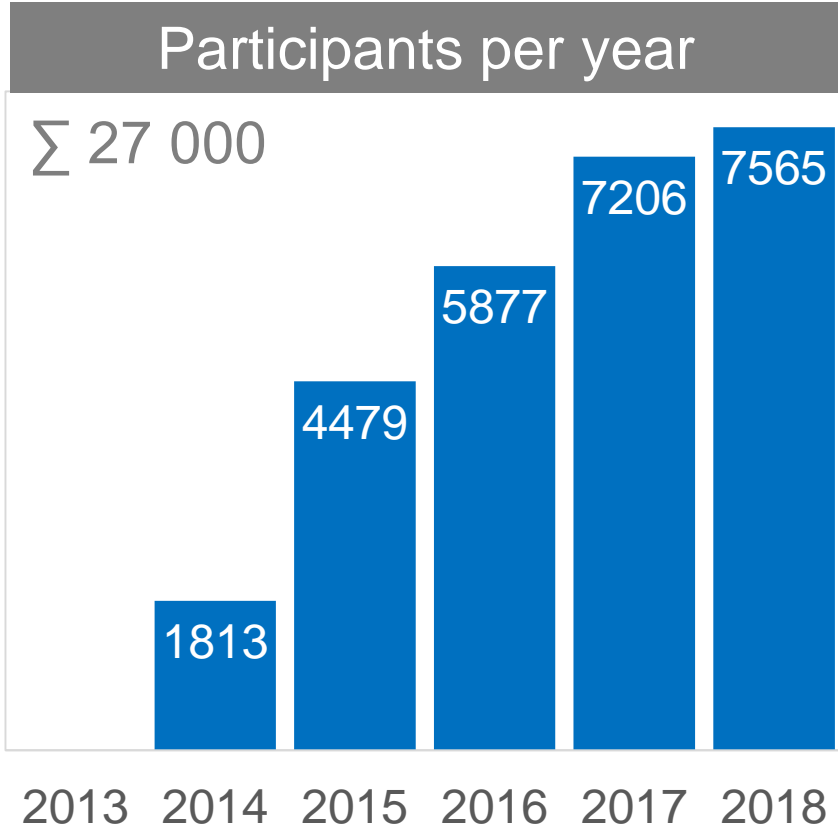
Summer CAMP



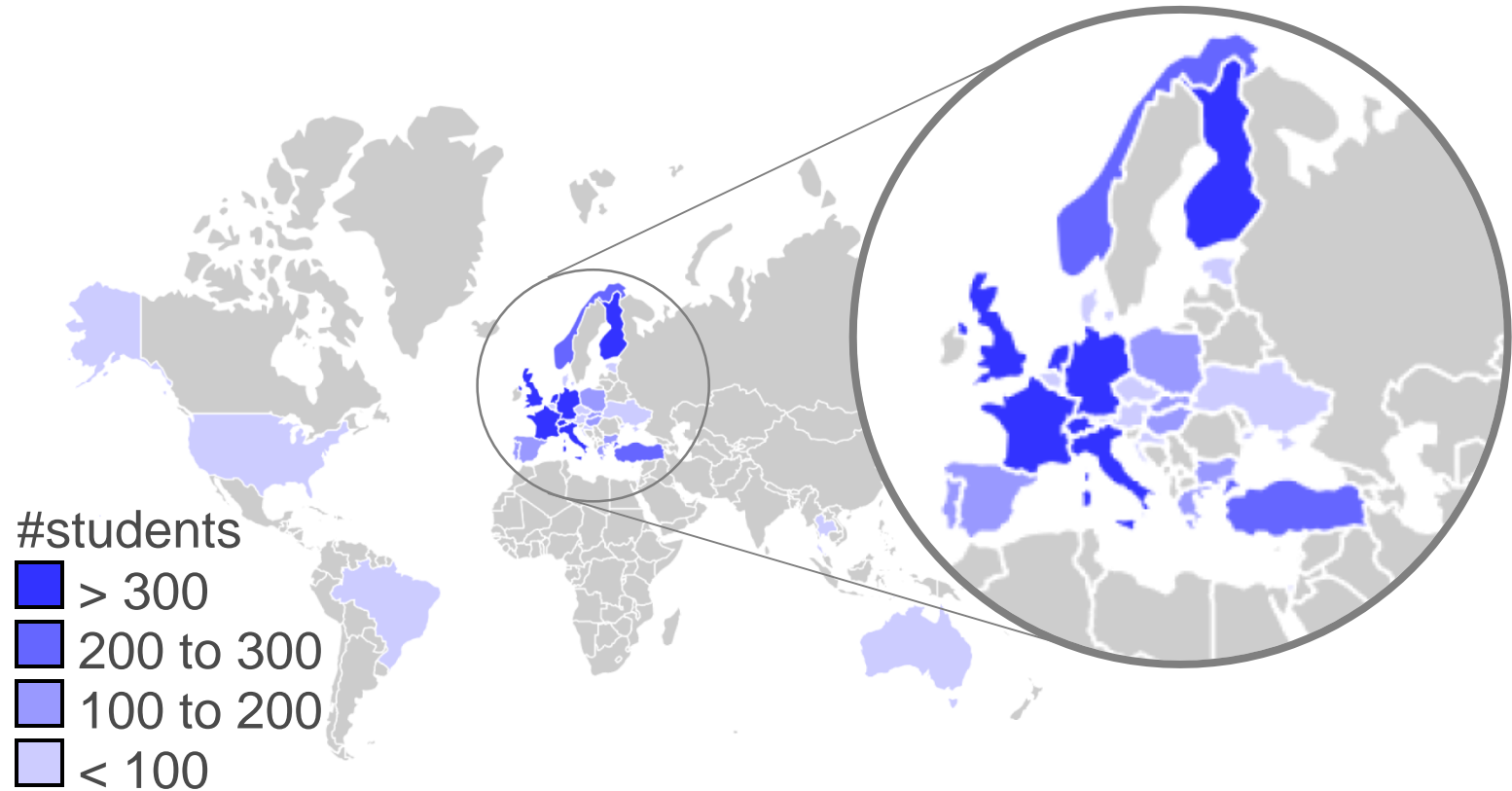
A two-week residential particle physics summer camp for 30 high school students aged 16-19 from all around the world.

2nd camp in 2018 (24/07 – 04/08)

S'Cool LAB participants



Student participants per country (2017)



Development of S'Cool LAB Activities



Hands-on experiments in the fields of particle detection, acceleration and medical applications to make CERN's physics understandable

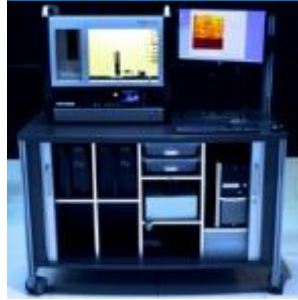
cloud
chambers



electrons &
magnetic
fields



X-ray
machines



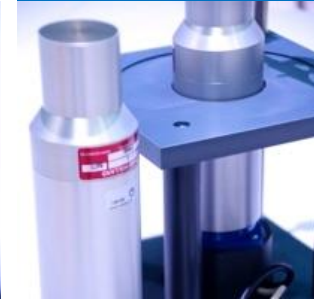
super-
conductivity



particle
traps



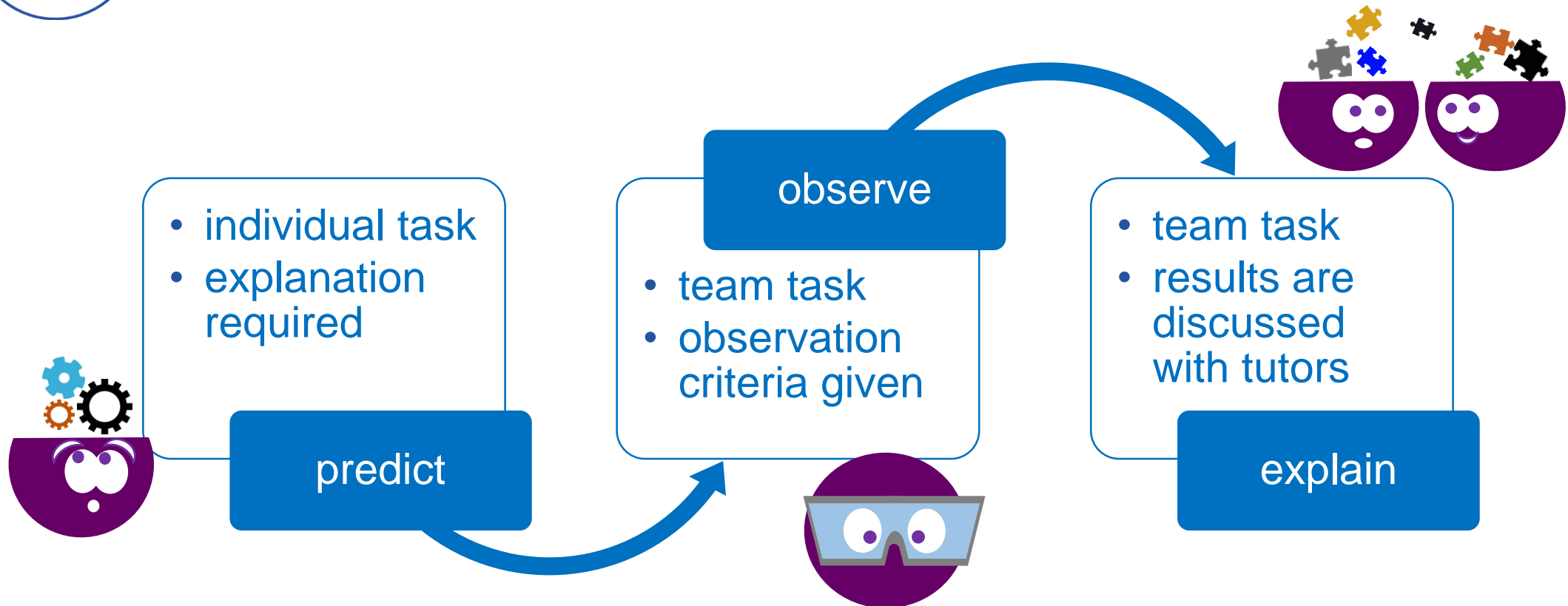
positron
emission
tomography



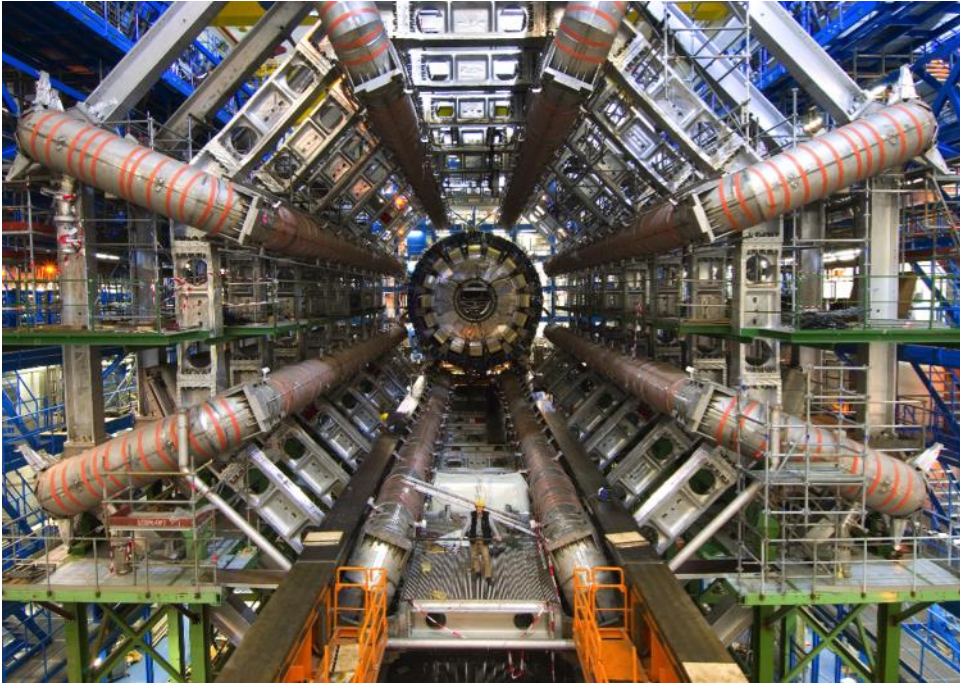
Development of S'Cool LAB Activities



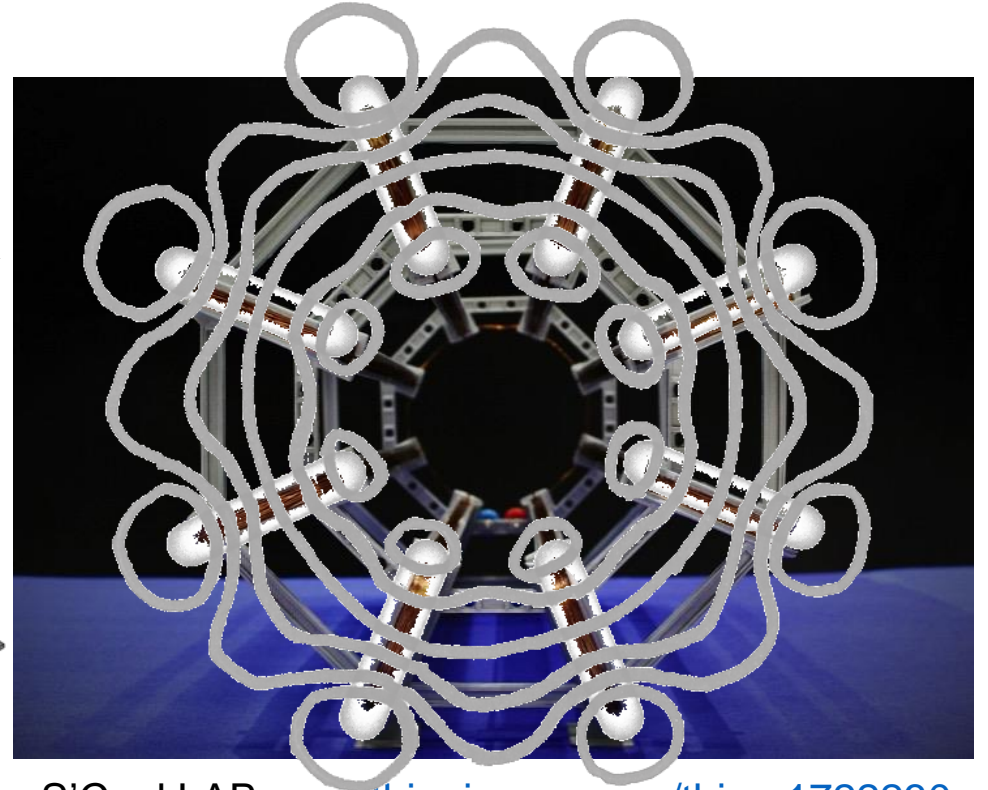
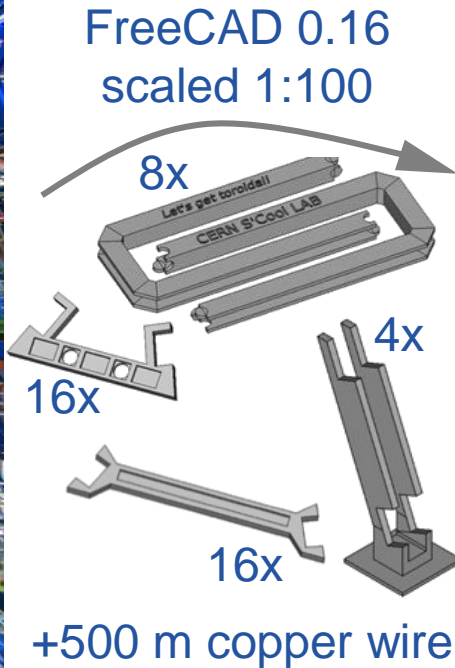
Minds-on experimental tasks structured in POE cycles (White & Gunstone, 1992) to keep students cognitively active



A 3D printable ATLAS magnet model



(Image: CERN)



S'Cool LAB www.thingiverse.com/thing:1722230



PARTICLE IDENTITIES



Réponds à 7 questions
et découvre quelle
particule élémentaire te
correspond le mieux !



Answer 7 questions
& find out which
particle best fits
your personality!

► cern.ch/identities

A hands-on tour through particle physics on a small budget

<https://scool.web.cern.ch/classroom-activities>

S'Cool LAB

A hands-on tour through particle physics on a small budget

#SCoolLAB #3dprinting #inquiry #play

Thousands of high-school students and their teachers from around the world take part in S'Cool LAB workshops every year. However, our capacity is limited, and we can only accommodate 10% of the student groups coming to CERN. Therefore, we started preparing hands-on particle physics activities for your classroom, which you can do with your students even if you cannot participate in a S'Cool LAB workshop. We like 3D printing, but you can build all our models with other materials as well. You can find all our resources online: scool.ch/s-cool-lab

Enjoy your tour!
Your S'Cool LAB team

1) Particle Identities & Other Games

Would you like to introduce your students to particle physics through games? Do you have some spare time at the end of the year and need something educational to occupy your students? Do you love both board games and particle physics? Have a look at a small selection of particle physics games you can use in your classroom and try out our Particle Identities quiz.

Congratulations!
According to your answers, the particle which fits your personality best is:

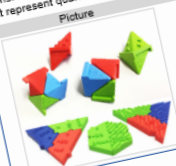


Go to scool.ch/quiz/ and answer 7 questions to find out which elementary particle best fits your personality.

Do you think your students would like the particle builder board game?

2) Quark Puzzle

Quarks are fundamental particles in the Standard Model of particle physics. They make up the protons and neutrons that we are familiar with, but also a zoo of other more exotic particle systems like pions and kaons. Find out more about the rules that govern these particle systems with a set of 3D printable pieces that represent quarks. You don't have a 3D printer? We also offer a paper version.



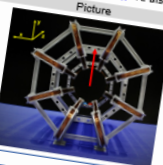
3D version:
Build a proton or a neutron.

2D version:
Can baryons have an electric charge of -2?

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3) ATLAS Toroidal Magnet Model

The ATLAS detector, the largest particle detector at the LHC, is one of the most complex machines ever built. However, due to its complexity, explaining the ATLAS detector at a high-school level can be challenging. We developed instructions how to build and study a model of the toroidal ATLAS magnet system. You don't have a 3D printer? We also offer a version with straw tubes and cardboard.

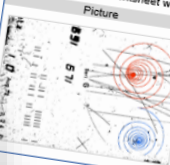


A muon is flying upwards from the collision point through the ATLAS toroid along the red arrow. How is it deflected in the magnetic field? A 3D compass might help you.

- a) x-axis
- b) y-axis
- c) z-axis

4) Bubble Chamber Worksheets

A bubble chamber is particle detector based on a container filled with a transparent liquid, which can make tracks of electrically charged particle visible. By studying the patterns of bubbles caused by particles when interacting with the liquid, physicist studied fundamental interactions between elementary particles. We developed student worksheet with original bubble chamber pictures from CERN.



On the front page of the booklet, 2 tracks are highlighted in red and in blue. What are they?

- a) positron and electron
- b) proton and anti-proton
- c) 2 photons

5) Quadrupole Ion Trap

Quadrupole ion traps can be used to trap electrically charged particles. At CERN, the GBAR experiment at the antimatter factory uses this type of particle trap to store anti-hydrogen-ions. We developed building instruction for a 3D-printable quadrupole ion trap capable of trapping electrically charged "macroscopic particles" such as cinnamon or lycopodium spores. You can also build the trap with other materials.



Which resistor is needed for the safe operation of the trap?

- a) 1 Ω
- b) 100 Ω
- c) 1 M Ω

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6) 3D-Printable Black Box

Black boxes are a great tool to practice scientific reasoning skills. Students develop hypotheses about the internal structure of a black box, and come up with ideas how to test their hypotheses through indirect observation. We know it's tempting, but never open the box, that's not how science works :) You don't have a 3D printer? Check out cardboard or pipe alternatives, e.g. here <https://resources.perimeterinstitute.ca>



Shake the black box and predict its internal structure. Test and adapt your hypothesis.



7) Scattering Experiment

Scattering experiments (e.g. Rutherford's gold foil experiment) are an important research tool of nuclear and particle physics. They help us to study interactions between particles and to obtain information about the structure of matter. You can introduce your students to the concepts of scattering experiments with everyday equipment such as marbles or tennis balls and cardboard, or use a 3D printer.

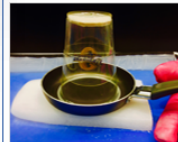


Direct the steel balls towards the target and try to identify the hidden shapes.

- a) circle
- b) triangle
- c) square
- d) 1/r potential

8) Our Favourite Experiment: The Cloud Chamber

The cloud chamber was one of the first particle detectors. It is very easy to build a cloud chamber with everyday material, dry ice, and Isopropyl alcohol. We developed a DIY manual including detailed instructions how to build a cloud chamber, and many information on how to interpret the observations.



Choose your favourite very-low-cost cloud chamber version. Do you have another idea?

- a) marmalade jar
- b) frying pan
- c) bookend version
- d) other ideas:

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9) Other Ideas:

Task: Talk to your neighbours to find out more about their favourite classroom activities in particle physics.

You can find many more hands-on activities online in different online databases. Have a look at the following resources:
e.g. The Black Box <https://resources.perimeterinstitute.ca/collections/process-of-science/products/the-black-box?variant=33202303110>

Resources collected by the International Particle Physics Outreach Group
e.g. The Black Box <https://resources.perimeterinstitute.ca/collections/process-of-science/products/the-black-box?variant=33202303110>

Resources collected by Instructables <https://www.instructables.com/group/physics/>

Resources collected by Masterclasses <https://physicsmasterclasses.org/>

Resources collected by Thinkiverse <https://www.thinkiverse.com/education/>

Resources collected by The Physics Classroom <https://www.physicsclassroom.com/>

Resources collected by The Physics Classroom <https://www.physicsclassroom.com/>

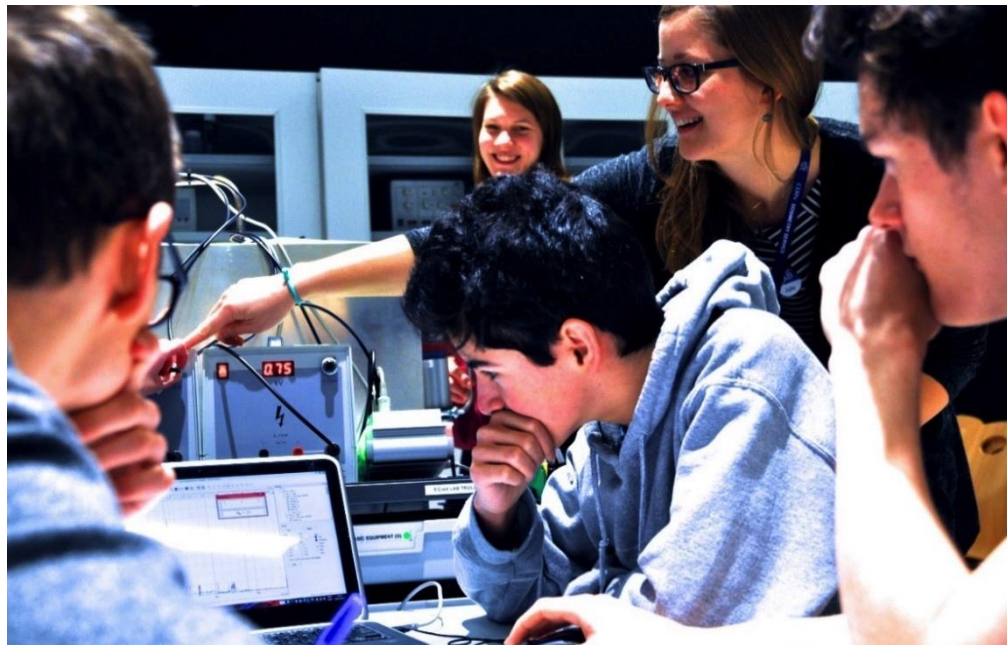
Resources collected by The Physics Classroom <https://www.physicsclassroom.com/>


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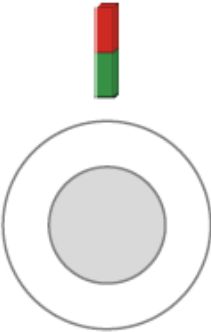

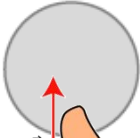

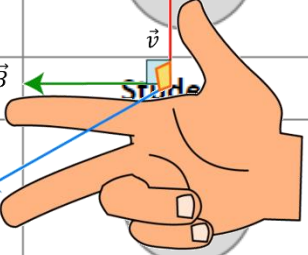


Development of S'Cool LAB Activities



Hearts-on interactions through challenging group work and diverse CERN volunteers (42% female) including Q&A with potential role models



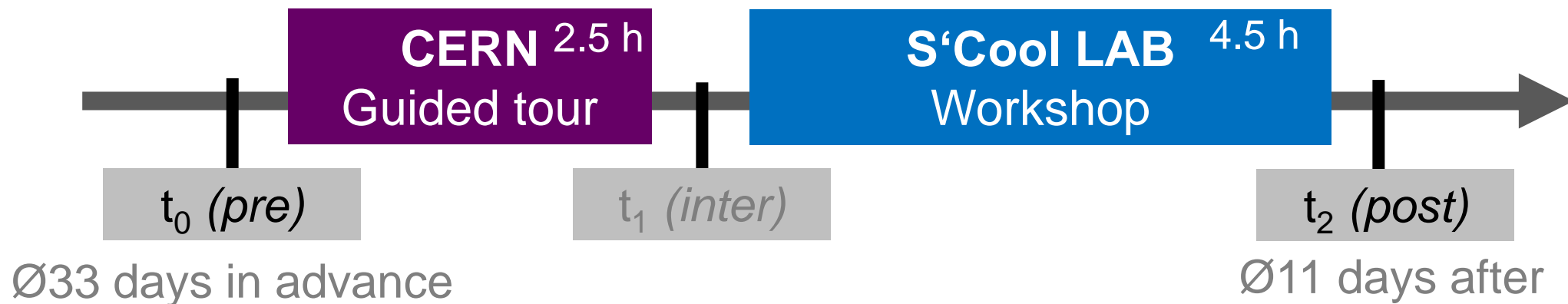
 **Prediction:** Mark your prediction for the position of the beam spot with a **cross X** for the 3 magnet positions below.

Magnet position 1	Student 1	Student 2	
			
	Student 3		
			

Main Study

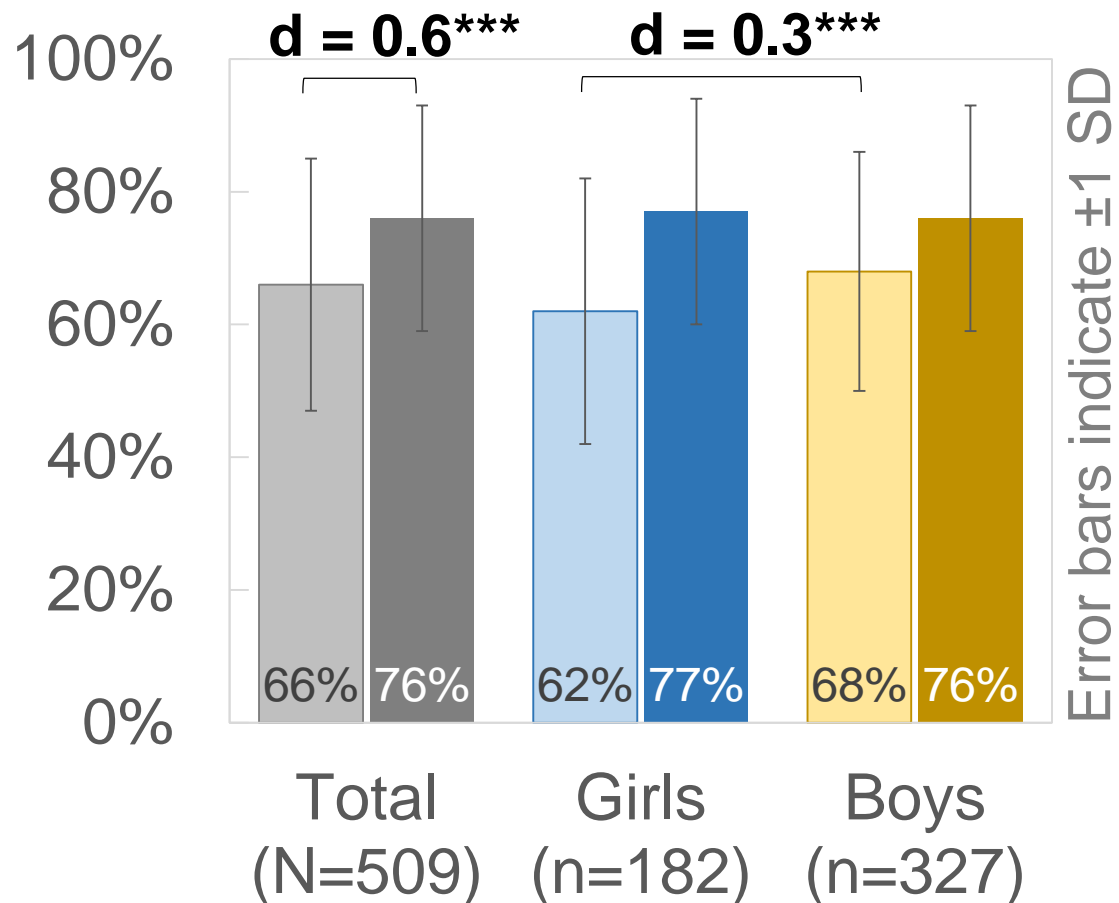
Research Design

- Single group, pre- and post-test research design with online questionnaires
- Intervention: 4.5 hour hands-on session
- Sample: 509 students in 28 groups from 69 teachers and 13 different countries
- N = 509 students, 36% female, M = 17.0y, SD = 0.9y



Main Study

Results: interest development



- Medium sized effect on interest
- Significant difference between girls and boys in dispositional interest (no sign. difference in physics grades)

$$d_{\text{Cohen}} = 0.3^{***}$$

$$\text{♀ } M = 0.62, \text{ SD} = 0.20$$

$$\text{♂ } M = 0.68, \text{ SD} = 0.18$$

$$t(507) = 3.3, p < 0.001$$

Main Study

Results: predictors interest/self-beliefs

z-score: situational interest	
Fixed part	β_s
intercept	0.00
disp. interest physics	0.12**
curiosity particle phys.	0.50***
experience hands-on	-0.01
experience osleos	-0.01
orientation/organisation	0.15***
cognitive load	0.01
tutor support	0.22***
Random part	var
student level variance	0.33 (0.74)
group level variance	0.05 (0.29)
modelled variance R ²	62%

NIFs

NEFs

z-score: situational self-beliefs	
Fixed part	β_s
intercept	0.01
disp. self-beliefs physics	0.21***
experience hands-on	-0.01
experience osleos	0.07
orientation/organisation	0.27***
cognitive load	-0.20***
tutor support	0.25***
Random part	var
student level variance	0.49 (0.86)
group level variance	0.04 (0.15)
modelled variance R ²	47%

NIFs

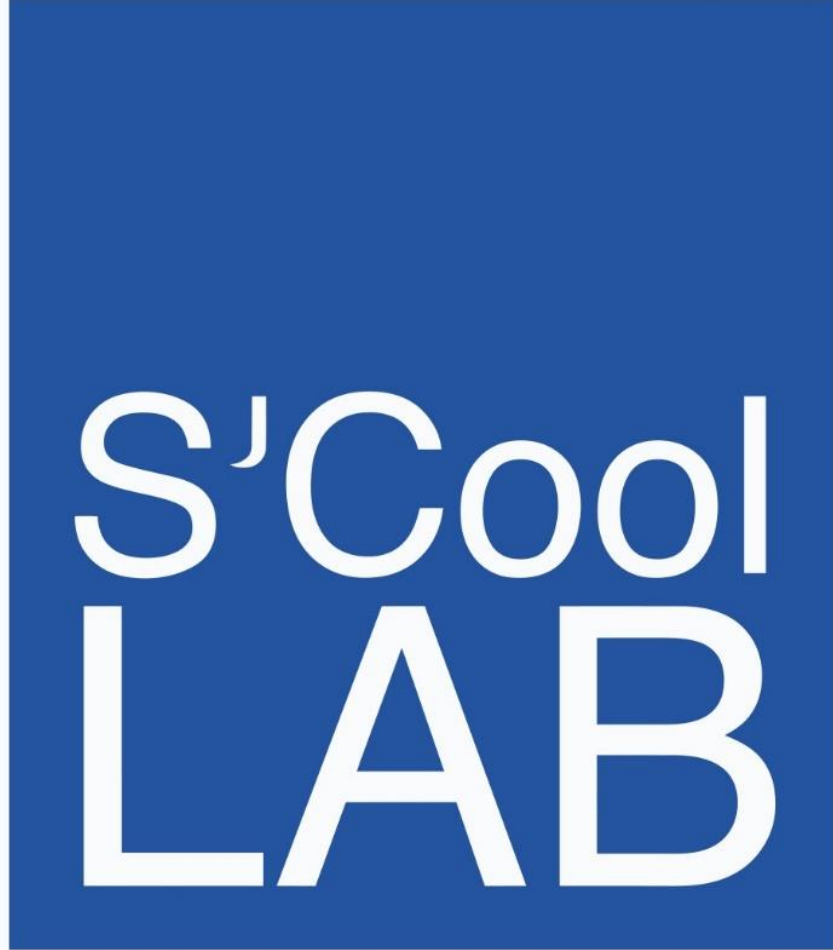
NEFs



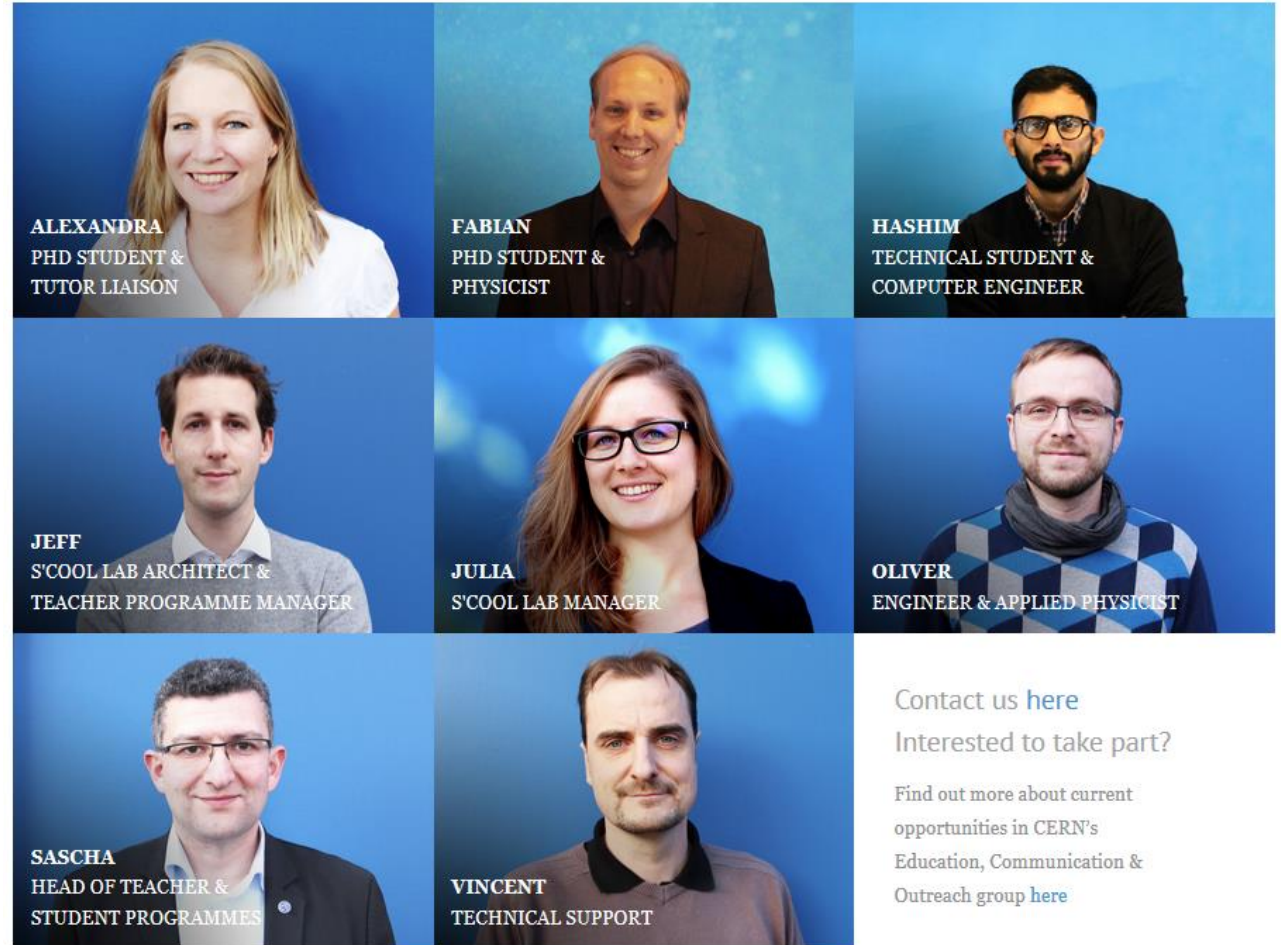
How to become a S'Cool LAB tutor

Do you like to discuss physics with high school students and teachers? Do you like to perform hands-on experiments? Do you have a physics background or you are interested in physics and willing to learn more? cern.ch/s-cool-lab/how-to-become-tutor

Other activities & fun facts

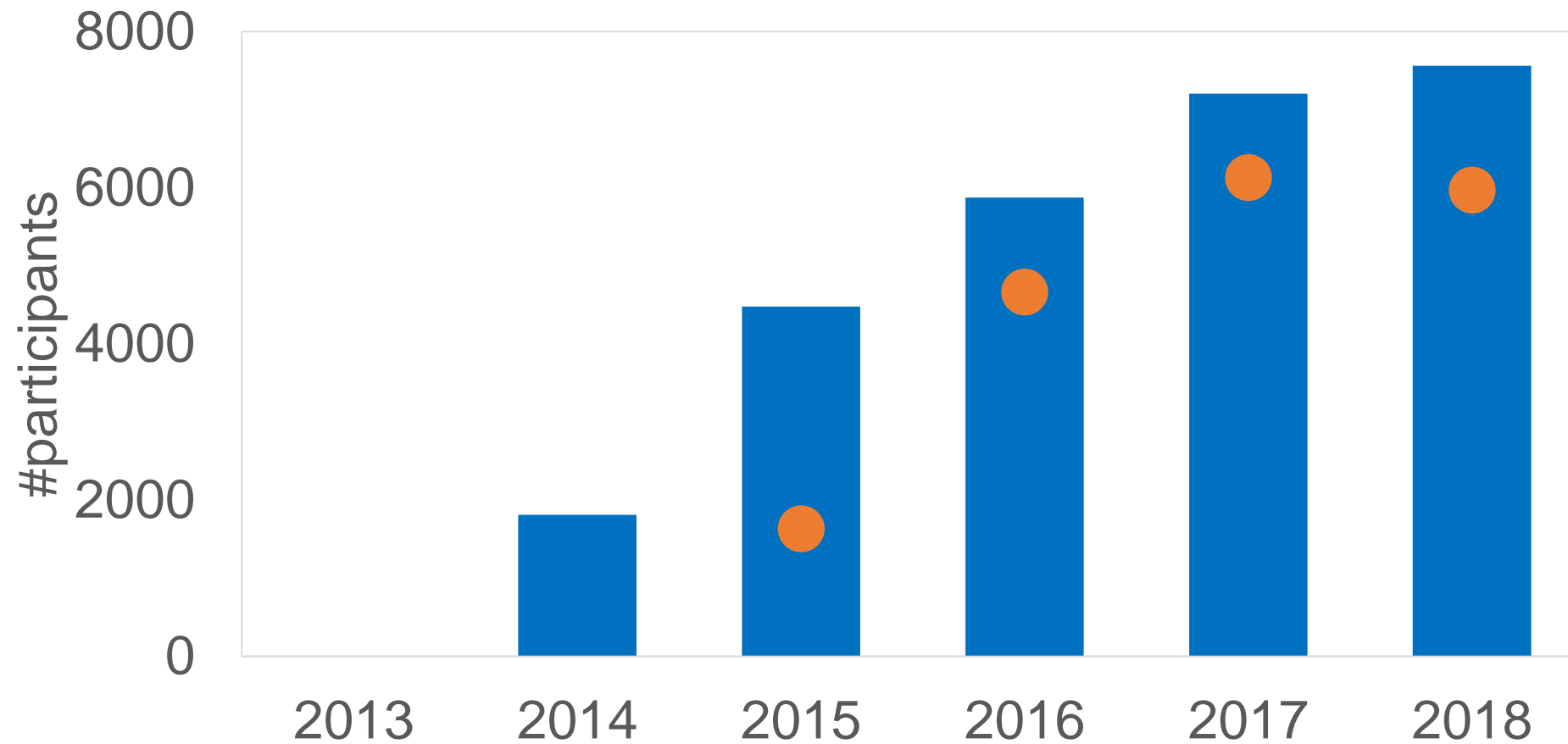


CERN S'Cool LAB | The complete story



<https://www.youtube.com/watch?v=tSqcxDdO43Q>

One more correlation ...





escape



Penguins stole an antimatter trap from CERN's antimatter factory. After playing hide and seek with it for an afternoon, they got distracted by the dry ice and liquid nitrogen in S'Cool LAB and forgot the antimatter on the table. Unfortunately, they forgot to switch on the time-super-warp-shift-nano-laser stabilizer. That means the antimatter trap will destabilize and the antimatter will annihilate with normal matter soon ...

We need you to

- Translate particle identities into more languages (SE, DK, NO, RO, IL, HU, FI, BG, BE, IN, LT, PK, UA, ...)
- Tell students & teachers from your country about S'Cool LAB
- Become a tutor
- scool.lab@cern.ch

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It's time for pizza & your questions!